PAN-PACIFIC ENTOMOLOGIST
66(1): 39–42, (1990)

A MORPHOMETRIC ANALYSIS OF *MELANOPLUS* FEMALES (ORTHOPTERA: ACRIDIDAE)

S. J. GUENTHER AND W. CHAPCO
University of Regina, Regina, Saskatchewan S4S 0A2, Canada

Abstract.—Females of certain species-groups in the genus *Melanoplus* are difficult to distinguish morphologically, especially for the novice. Three linear discriminant functions based upon morphometric traits are defined that allow separation of females of *M. sanguinipes* Fabr. from each of *M. femurrubrum* De Geer, *M. confusus* Scudder, and *M. gladstoni* Scudder.

Key Words.—Insecta, Orthoptera, Acrididae, *Melanoplus,* discriminant function

Species of *Melanoplus* are conventionally identified by genital characters of the male. Females of certain species-groups, however, are difficult to distinguish, especially for the novice. One practice is to associate co-occurring females with identified males; this is probably satisfactory if males of no other *Melanoplus* species are found. Nevertheless, congeneric species do often appear in the same location. It is not uncommon to find *M. sanguinipes* Fabr. associated with *M. femurrubrum* De Geer, *M. confusus* Scudder, and *M. gladstoni* Scudder. Features used to distinguish *M. sanguinipes* from these species are unreliable. For instance, the red-legged trait of *M. femurrubrum* also occurs polymorphically in *M. sanguinipes* (Chapco 1983). The early spring emergence of *M. confusus* can aid in its separation from *M. sanguinipes,* but by late June adults of both species are found. The more robust *M. gladstoni* is less difficult to distinguish from *M. sanguinipes.* Pale laterodorsal lines which form a diamond-back marking are common in the former, but *M. sanguinipes* also has this trait polymorphically (Bidochka 1984). Brooks' (1958) monograph on Acridoidea of the Canadian Prairies states that there are differences in the dorsal angle of ovipositor among *Melanoplus* species, but we have found considerable variation for the trait; moreover, its measurement is awkward. We demonstrate that discriminant functions based on a few easily made measurements can, with reasonable confidence, help separate *M. sanguinipes* from *M. femurrubrum, M. confusus* and M. *gladstoni.*

MATERIALS AND METHODS

Eleven morphometric traits were determined for roughly 30 specimens per species: prozona length (PZL), metazona length (MZL), pronotum width (PRW), head width (HW), eye height (EH), eye width (EW), femur length (FL), femur width (FW), tibia length (TL), interoccular distance (ID), and suboccular suture length (SSL). Traits can be easily measured to the nearest 0.5 mm with calipers. *Melanoplus sanguinipes, M. femurrubrum,* and *M. confusus* were collected within a 20 km radius of Regina, Saskatchewan; *M. gladstoni* were collected at the Last Mountain House Historical site, about 45 km NW of Regina.

RESULTS AND DISCUSSION

Table 1 shows mean values for each trait and species; pooled within species mean square errors (MSE) provide measures of variability. Because analysis of

variance (not shown) revealed significant interspecific variation for all traits, a Duncan's multiple range test ($\alpha = 0.01$) was used to determine homogeneous groupings. Uniform sets are indicated by common letters (a, b, . . .) in the table. Although *Melanoplus femurrubrum* appears as the smaller species in Table 1, there is no consistent ranking among the other species. Many of the shape indices (ratios of various traits such as MZL/PZL, TL/FL, etc., see Eades 1970) customarily used in morphometric investigations of acridids were calculated, but interestingly, with a few exceptions (see below), these showed considerable overlap among species. Allometric similarity for body proportions may, therefore, explain why some *Melanoplus* groups are difficult to identify.

Discriminant functions (DF) between *M. sanguinipes* and each of the other three species were arrived at by applying stepwise discriminant analysis (Wilks) to all variables and to subsets of variables and derived ratios (e.g., MZL/PZL, PZL/FW, etc.). Those sets with the largest discriminatory power (percentage of correctly classified specimens) were retained.

Resultant discriminant functions and classification rules follow:

1. *M. sanguinipes* vs. *M. femurrubrum*:

$$DF = (-11.0366) + (0.8882 \times (TL)) - (9.3904 \times (PZL/FW)) + (0.7142 \times (FL))$$

If DF < 0.0787, classify as *M. femurrubrum.*
If DF > 0.0787, classify as *M. sanguinipes.*
96.6% correct classification

2. *M. sanguinipes* vs. *M. confusus*:

$$DF = (-10.2199) + (3.1389 \times (FW)) - (4.0698 \times (PZL)) + (2.0752 \times (HW)) - (1.9843 \times (SSL)) + (0.9190 \times (FL)) - (1.0061 \times (TL) + (1.1778 \times (EH))$$

If DF < 0, classify specimen as *M. confusus.*
If DF > 0, classify specimen as *M. sanguinipes.*
96.4% correct classification.

3. *M. sanguinipes* vs. *M. gladstoni*:

$$DF = (-13.3864) - (1.8198 \times (EW)) + (2.1149 \times (FL)) - (1.7867 \times (PZL + MZL))$$

If DF < 0.0984, classify specimen as *M. gladstoni.*
If DF > 0.0984, classify specimen as *M. sanguinipes.*
98.3% correct classification.

Traits are not difficult to measure although the inclusion of seven variables in the separation of *M. sanguinipes* and *M. confusus* may be bothersome to some investigators. An alternative discriminant function based on five variables yielded 92.7% correct classification and may be more attractive. This is given by

$$DF = (-0.6759) - (1.2193 \times (FL)) + (1.0714 \times (TL)) - (1.6382 \times (EH)) + (12.0694 \times (PZL/FW)).$$

To classify specimens, their character measurement values are substituted into

Table 1. Mean values for 11 morphometric traits for four *Melanoplus* species. Letters following values indicate homogeneous subsets of species. MSE = mean square error with df = 111. See text for meaning of other symbols.

Trait	*fem*	*sang*	*conf*	*glad*	MSE
PZL	2.10a	2.29b	2.58c	2.32b	0.054
MZL	2.33a	2.77c	2.63bc	2.53b	0.060
PRW	3.20a	3.71b	3.78bc	3.92c	0.060
HW	3.70a	4.28b	4.15b	4.17b	0.064
EH	2.22a	2.43b	2.25a	2.43b	0.047
EW	1.52a	1.71b	1.52a	1.83c	0.034
FL	11.32a	13.02b	12.69b	11.17a	0.451
FW	2.98a	3.55d	3.22b	3.38c	0.049
TL	9.18a	10.59b	10.74b	9.33a	0.312
IND	0.93a	1.00ab	1.00ab	1.05b	0.013
SSL	1.50a	1.57a	1.52a	1.80b	0.052
Sample *n*	30	28	27	30	111(df)

the appropriate discriminant function and their DF scores are assessed accordingly. For example, one specimen suspected to be *M. femurrubrum* had the following measurements: TL = 9.0, PZL = 2.0, FW = 3.0, FL = 10.5. Substitution into the first discriminant function yielded a discriminant score DF = (−11.0366) + (0.8882 × (9.0)) − (9.3904 × (2.0/3.0)) + (0.7142 × (10.5)) = −1.80. Because −1.80 < 0.0787, the specimen is identified as *M. femurrubrum*.

It is not known whether these discriminant functions can be applied to specimens outside the geographic range of the present collection; this is currently being investigated. Because the samples used to establish the DFs were the same as those used to test the procedure, quoted discriminatory powers are likely overestimates of true values. A more appropriate test of discriminatory power could be achieved by randomly splitting samples into parts and using one part for DF construction and the other part for assessing power. Although sample sizes larger than those used here are usually required, the procedure was tried using the same variables as above. Discriminatory powers then dropped to 84.0%, 66.7% and 90.6% for "unknown" samples of *M. sanguinipes* and each of *M. femurrubrum, M. confusus,* and *M. gladstoni,* respectively. For the alternative DF involving *M. confusus,* the percentage of correctly classified specimens remained high at 92.3%. Despite shortcomings our procedure illustrates that a high degree of discrimination among morphologically similar females of different species is possible using relatively few variables; researchers in other locations could define similar functions.

Acknowledgment

We thank the Natural Sciences and Engineering Research Council of Canada (Grant A-0485 to WC) for financial support.

Literature Cited

Bidochka, M. J. 1984. Genetic variation in natural populations of the migratory grasshopper, *Melanoplus sanguinipes.* M.Sc. Thesis, University of Regina.

Brooks, A. R. 1958. Acridoidea of southern Alberta, Saskatchewan and Manitoba (Orthoptera). Can. Entomol., Supl. 9.

Chapco, W. 1983. The genes, T^R, Ost, Pro^R and L in natural populations of *Melanoplus sanguinipes*. Can. J. Genet. Cytol., 25: 88–92.

Eades, D. C. 1970. Theoretical and procedural aspects of numerical phyletics. Syst. Zool., 19: 142–171.

Received 10 April 1989; accepted 7 November 1989.